Remote monitoring of people with dementia: the Dem@Care Experience

Outline

• Overview
  • Vision, objectives
• Sensing Solutions
  • Sensing modalities and sensors
• Fusion and Interpretation Services
• Feedback & Visualisations
• Pilots
Dem@Care Vision and Objectives

• A close-loop multi-parametric remote monitoring framework
  • For timely diagnosis, assessment, maintenance and promotion of self independence of people with dementia
• Enhance clinical workflow by
  • Continuous monitoring the condition and progress of PwD
  • Providing objective multi-sensor measurements
• Connect monitoring results with dementia staging and to assist diagnosis
• Enhance a sense of safety and increased autonomy and QoL
  • Relieve informal carers
  • Reduce care costs (e.g. reduce the number of visits)
Dem@Care Approach

• Focus on three directions:
  • Implementation of multi-sensor monitoring and analysis of behaviour
  • Support person-tailored, time-evolving behaviour profiling & interpretation
  • Support feedback for personalized treatment and care
The Dem@Care Platform

• Multisensor monitoring and feedback solutions

• Key Features
  • Continuous sensor-based monitoring of various modalities & functional areas
  • Integration, analysis and interpretation of sensor measurements
  • Personalized high-level descriptions of the person’s condition and its evolution over time
  • Easy-to-use interfaces for the people with dementia and their caregivers/clinicians
Dem@Care Technology stack

Hardware Layer (sensors)

Persistence Layer

Intermediate Analysis Layer

Service Layer

Presentation Layer

Relational DB (MySQL)

Ontology-based fusion and analysis

Web Services (WSDL/SOAP)

Controller

Graphical User Interfaces

Object detection, room recognition, postures, power consumption, speech analysis

Semantic (high-level) Analysis Layer

Visualisations

Presence, Motion, Depth/Wearable Cameras, Wristwatch, Sleep, Mic...

Dem@Care Technology stack
Dem@Care Sensing Solutions

• Five areas of interest determined by clinical experts
  • Social activity
    • Number of social interactions
  • Sleep
    • Quality (e.g. duration, number of interruptions, etc.)
  • Physical activity
    • Level of activity during the day
  • Activities of Daily Living (ADLs)
    • Duration, repetitions, etc.
  • Mood
Sensors & Analytics (1)

• Video Analytics
  • Wearable and ambient cameras
  • Detection and recognition of ADLs, objects and places
  • Monitoring of daily life patterns (e.g. execution of ADLs over time)

• Speech Analytics
  • Ambient microphones / Smart phones
  • Assessment of person’s emotional and cognitive status
  • Assessment of levels of sociability: increased speech with other individuals indicates higher levels of sociability

• Physiological Measurement Analytics
  • Wrist worn devices
  • Physiological measurements (e.g. heart rate)
  • Physical activity assessment (e.g. steps)
  • Assessment of stress
Sensors & Analytics (2)

• Utilities usage
  • Smart plugs (power consumption)
  • Monitoring of lifestyle

• Use of daily living objects
  • Motion sensors attached to objects
  • Assessment/logging of daily activities carried out

• Presence of people in certain rooms
  • PIR Sensors (Passive Infra-Red)
  • e.g. bathroom visits

• Qualitative and quantitative analysis of sleep patterns and quality
  • Mattress sensor
  • Detection of interruptions of sleep, duration, etc.
Fusion and Interpretation

• The individual pieces of information are not capable of describing the behavior of the person
• Combined pieces of information can provide meaningful interpretations

Dem@Care approach
  • High-level aggregated interpretation of sensory observations
    • Identify clinically relevant situations, problems and behaviours

Challenges
  • Efficient representation of heterogeneous information
    • e.g. cameras, microphones, activities, measurements
  • Intelligent reasoning mechanisms
    • e.g. inference of complex activities/situations, problems, etc.
Dem@Care Ontologies

• Lab ontology
  • formalises the information relevant to the lab environment (e.g. protocol steps, measurements, etc.)

• Home & Nursing home ontology
  • formalises information relevant to the home and nursing home environments (e.g. functional problems)

• Event ontology
  • formalises information relevant to the entities and events considered within the Dem@Care system (e.g. persons, objects, activities, etc.)
High-level Assessment

• Detection of problematic situations
  • Lab (e.g. missed activities)
  • Home/Nursing Home (e.g. sleep problems, reoccurring problems)

• Extraction of high-level person-tailored norms/patterns
  • Duration/frequency of certain activities
  • Deviations from normal behavior

• Correlations
  • e.g. correlations between physical activity and sleep problems (such as, when low physical activity affects the quality of sleep)
Feedback and Visualisations (1)

- To person
  - Reminders (questionnaires, appointments, etc.), suggestions
Feedback and Visualisations (2)

• To caregivers & clinicians
  • More detailed insights into the person’s daily life
  • e.g. activities carried out during the day
Feedback and Visualisations (3)

- Problems, e.g. stress levels, insufficient social interactions ...
- Draw conclusions about dementia and factors that lead to its worsening or improvement
  - Adapt interventions
Feedback and Visualisations (4)

• Comparisons and correlations

A day of high activity was followed by uninterrupted, high quality sleep
Installations and Pilots (Ongoing)

• **Lab (diagnostic support and assessment)**
  - Nice: 105 participants (ambient and wearable camera, microphone, activity sensor)
  - Thessaloniki: 74 participants (ambient, microphone, activity, motion and plug sensors)
  - Preliminary results: the system can be used to differentiate between the different severity stages of dementia, from the early pre-demented on to more severe stages

• **Home (enablement and independence)**
  - Dublin: 6 participants (wearable camera, sleep and activity sensors)
  - Thessaloniki: 4 participants (full set of sensors)
  - Improvements: Sleep quality (less night sleep interruptions, less TV watching lead to more sleep, daily routine (active participation in ADLs)

• **Nursing home (staff support and PwD safety)**
  - Lulea: 4 users in 2 nursing homes (sleep and activity sensors)
  - Nice: 2 people in 2 nursing homes (ambient camera and activity sensor)
Thank you!

http://www.demcare.eu
Visual Analytics (1)

• Video monitoring and construction of behavioural patterns.
• Activity detection and recognition at home and lab environments

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<th>ADL</th>
<th>Recall</th>
<th>Precision</th>
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<td>75.0%</td>
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<td>23.5%</td>
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<td>Tea Preparation</td>
<td>100.0%</td>
<td>64.3%</td>
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<tr>
<td>Turn On Radio</td>
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Visual Analytics (2)

• Static RGB – D camera:
  • Person, posture localization in pre-defined areas of a room
  • Smoothed tracking, re-identification of person (e.g. after occlusion)
  • 3D geometric and semantic information, event models
  • High recognition rates for ADLs
<table>
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<th>AnswerPhone Suc. Attempts</th>
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<th>PrepareDrugBox Suc. Attempts</th>
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